

1 WHAT IS CLAIMED IS:

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3 1. A system for monitoring a plurality of cell voltages of an
4 electrochemical device for a plurality of cells connected in series, the
5 system comprising:

6

7 (a) a plurality of connecting pins for removable connection across
8 the plurality of cells;

9

10 (b) a plurality of differential amplifiers, each differential amplifier
11 having a plurality of laser wafer trimmed resistors providing
12 matching, so that common mode signals are rejected, while
13 differential input signals are amplified, each differential amplifier
14 having two inputs and one output, wherein the inputs are each
15 connected to the plurality of connecting pins;

16

17 (c) a switching network having a plurality of inputs and one output,
18 the inputs of the switching network connected to the outputs of
19 the differential amplifiers;

20

21 (d) not more than one analog to digital converter per 16 cells having
22 an input connected to the output of the switching network and
23 adapted to provide digital values indicative of the voltages
24 measured by the plurality of differential amplifiers; and

25

26 (e) a power supply to supply regulated power to at least one
27 electrical circuit consisting of the differential amplifiers, switching
28 network, and mixtures thereof, wherein the power supply derives
29 its power from the plurality of cells.

- 1 2. The system of claim 1, further comprising a controller connected to the
2 switching network and the analog to digital converter to control the
3 operation of the switching network and the analog to digital converter,
4 wherein the controller is further adapted to receive the digital values
5 from the output of the analog to digital converter.
6
- 7 3. The system of claim 1, wherein the plurality of cells comprise fuel cells.
8
- 9 4. The system of claim 1, wherein the plurality of cells comprise battery
10 cells.
11
- 12 5. The system of claim 1, wherein said plurality of cells have a cumulative
13 maximum voltage of about 270 volts.
14
- 15 6. The system of claim 4, wherein each cell has a maximum voltage of
16 about +/- 300 volts.
17
- 18 7. The system of claim 1, wherein said differential amplifiers each
19 produce an output such that the voltage of a cell being measured is
20 determined with an error of about 0.02 percent or less.
21
- 22 8. The system of claim 1, wherein said differential amplifiers each
23 produce an output such that the voltage of a cell being measured is
24 determined with a gain nonlinearity error of about 3 parts per million or
25 less.
26
- 27 9. The system of claim 1, further comprising a single housing, wherein
28 each system component is housed therein.
29
- 30 10. The system of claim 9, wherein each single housing and system
31 component housed therein comprises a module for monitoring the
32 voltage of least 16 cells, and further comprising at least 16 of the

- 1 modules configured to monitor cell voltages of least 256 cells of a
2 single cell stack.
3
- 4 11. The system of claim 1, wherein the system further includes a
5 calculating means, connected to the output of one of the analog to
6 digital converters and the controller, to calculate the at least one cell
7 voltage based on the digital values.
8
- 9 12. The system of claim 1, wherein each differential amplifier is adapted to
10 reject a common-mode voltage of at least +/-270 volts.
11
- 12 13. The system as claimed in claim 1, wherein the controller comprises a
13 microprocessor.
14
- 15 14. The system as claimed of claim 1, wherein the system further
16 comprises a computer and the controller is connected to the computer.
17
- 18 15. A system for monitoring a plurality of cell voltages of a fuel cell stack or
19 battery bank having a plurality of cells connected in series, the system
20 comprising:
21
- 22 (a) a plurality of connecting pins for removable connection across
23 the plurality of cells, the plurality of cells having a cumulative
24 maximum voltage of at least about 225 volts;
25
- 26 (b) a plurality of differential amplifiers, each differential amplifier
27 having a plurality of laser wafer trimmed resistors providing
28 matching, so that common mode signals are rejected, while
29 differential input signals are amplified, wherein said differential
30 amplifiers each produce an output such that the voltage of a cell
31 being measured is determined with an error of about 0.02
32 percent or less, each differential amplifier having two inputs and

1 one output, wherein the inputs are each connected to the
2 plurality of connecting pins,
3

4 (c) a switching network having a plurality of inputs and one output,
5 the inputs of the switching network connected to the outputs of
6 the differential amplifiers;
7

8 (d) not more than one analog to digital converter per 16 cells having
9 an input connected to the output of the switching network and
10 adapted to provide digital values indicative of the voltages
11 measured by the plurality of differential amplifiers;
12

13 (e) a power supply to supply regulated power to at least one
14 electrical circuit consisting of the voltage dividers, differential
15 amplifiers, switching network, and mixtures thereof, wherein the
16 power supply derives its power from the plurality of cells; and
17

18 (f) a single housing, wherein each system component is housed
19 therein.
20

21 16. The system of claim 15, wherein each single housing and system
22 component housed therein comprises a module for monitoring the
23 voltage of least 16 cells, and further comprising at least 16 of the
24 modules configured to monitor cell voltages of least 256 cells of a
25 single cell stack.
26

27 17. The system of claim 15, further comprising a controller connected to
28 the switching network and the analog to digital converter to control the
29 operation of the switching network and the analog to digital converter,
30 wherein the controller is further adapted to receive the digital values
31 from the output of the analog to digital converter.

- 1 18. The system of claim 15, wherein the plurality of cells comprise fuel
2 cells.
3
- 4 19. The system of claim 15, wherein the plurality of cells comprise battery
5 cells.
6
- 7 20. The system of claim 15, wherein said plurality of cells have a
8 cumulative maximum voltage of not more than about 270 volts.
9
- 10 21. The system of claim 19, wherein each cell has a maximum voltage of
11 about +/-300 volts.
12
- 13 22. The system of claim 15, wherein said differential amplifiers each
14 produce an output such that the voltage of a cell being measured is
15 determined with a gain nonlinearity error of about 3 parts per million or
16 less.
17
- 18 23. The system of claim 15, wherein the system further includes a
19 calculating means, connected to the output of one of the analog to
20 digital converters and the controller, to calculate the at least one cell
21 voltage based on the digital values.
22
- 23 24. The system of claim 15, wherein each differential amplifier is adapted
24 to reject a common-mode voltage of at least +/-270 volts.
25
- 26 25. The system as claimed in claim 15, wherein the controller comprises a
27 microprocessor.

1 26. A system for monitoring a plurality of cell voltages of a fuel cell stack
2 having a plurality of cells connected in series, the system comprising:
3
4 (a) a plurality of connecting pins for removable connection across the
5 plurality of cells, the plurality of cells having a cumulative maximum
6 voltage of at least about 250 volts;
7
8 (b) a plurality of differential amplifiers, each differential amplifier having
9 a plurality of laser wafer trimmed resistors providing matching, so
10 that common mode signals are rejected, while differential input
11 signals are amplified, wherein each differential amplifier is adapted
12 to reject a common-mode voltage of at least +/-270 volts, wherein
13 said differential amplifiers each produce an output such that the
14 voltage of a cell being measured is determined with a gain
15 nonlinearity error of about 3 parts per million or less, each
16 differential amplifier having two inputs and one output, wherein the
17 inputs are each connected to the plurality of connecting pins;
18
19 (c) a switching network having a plurality of inputs and one output, the
20 inputs of the switching network connected to the outputs of the
21 differential amplifiers;
22
23 (d) not more than one analog to digital converter per 16 cells having
24 an input connected to the output of the switching network and
25 adapted to provide digital values indicative of the voltages
26 measured by the plurality of differential amplifiers;
27
28 (e) a power supply to supply regulated power to at least one electrical
29 circuit consisting of the voltage dividers, differential amplifiers,
30 switching network, and mixtures thereof, wherein the power supply
31 derives its power from the plurality of cells; and

- 1 (f) a single housing, wherein each system component is housed
2 therein.
3
- 4 27. The system of claim 26, wherein each single housing and system
5 component housed therein comprises a module for monitoring the
6 voltage of least 16 cells, and further comprising at least 16 of the
7 modules configured to monitor cell voltages of least 256 cells of a
8 single cell stack.
9
- 10 28. The system of claim 26, further comprising a controller connected to
11 the switching network and the analog to digital converter to control the
12 operation of the switching network and the analog to digital converter,
13 wherein the controller is further adapted to receive the digital values
14 from the output of the analog to digital converter.
15
- 16 29. The system of claim 26, wherein said plurality of cells have a
17 cumulative maximum voltage of about 270 volts.
18
- 19 30. The system of claim 26, wherein each cell has a maximum voltage of
20 about +/-1 volts.
21
- 22 31. The system of claim 26, wherein said differential amplifiers each
23 produce an output such that the voltage of a cell being measured is
24 determined with an error of about 0.02 percent or less.
25
- 26 32. The system of claim 26, wherein the system further includes a
27 calculating means, connected to the output of one of the analog to
28 digital converters and the controller, to calculate the at least one cell
29 voltage based on the digital values.
30
- 31 33. The system as claimed in claim 26, wherein the controller comprises a
32 microprocessor.

- 1 34. The system as claimed of claim 26, wherein the system further
2 comprises a computer and the controller is connected to the computer.
3
- 4 35. A method for monitoring a plurality of cell voltages of an
5 electrochemical device for a plurality of cells connected in series and
6 having output terminals, the method comprising the steps of:
7
- 8 (a) connecting the voltages from the terminals of each cell to the
9 inputs of a differential amplifier, each differential amplifier having
10 a plurality of laser wafer trimmed resistors providing matching,
11 so that common mode signals are rejected, while differential
12 input signals are amplified, each differential amplifier having two
13 inputs and one output;
14
- 15 (b) rejecting the common-mode voltage from the voltages at the
16 terminal of each cell, in the differential amplifier, to give the
17 voltage differential between the two terminals;
18
- 19 (c) converting the voltage differential from analog to digital values;
20 and
21
- 22 (d) powering the differential amplifier with a power supply to supply
23 regulated power, wherein the power supply derives its power
24 from the plurality of cells.
25
- 26 36. The method as claimed in claim 35, the plurality of cells having a
27 cumulative maximum voltage of at least about 250 volts.
28
- 29 37. The method as claimed in claim 35, which includes connecting the
30 outputs of the differential amplifiers through a switching network to an
31 analog to digital converter, using the switching network to switch the
32 output of one of the differential amplifiers to the analog to digital

- 1 converter for analog to digital conversion of the voltage differential at
2 the output of said one differential amplifier.
3
- 4 38. The method claim 35, further comprising connecting the switching
5 network and the analog to digital converter to a controller to control the
6 operation of the switching network and the analog to digital converter,
7 wherein the controller is further adapted to receive the digital values
8 from the output of the analog to digital converter.
9
- 10 39. The method of claim 35, wherein the plurality of cells comprise fuel
11 cells.
12
- 13 40. The method of claim 35, wherein the plurality of cells comprise battery
14 cells.
15
- 16 41. The method of claim 35, wherein said plurality of cells have a
17 cumulative maximum voltage of about 270 volts.
18
- 19 42. The method of claim 35, wherein each cell has a maximum voltage of
20 about +/-300 volts.
21
- 22 43. The method of claim 35, wherein said differential amplifiers each
23 produce an output such that the voltage of a cell being measured is
24 determined with an error of about 0.02 percent or less.
25
- 26 44. The method of claim 35, wherein said differential amplifiers each
27 produce an output such that the voltage of a cell being measured is
28 determined with a gain nonlinearity error of about 3 parts per million or
29 less.
30
- 31 45. The method of claim 35, further comprising a single housing, wherein
32 each system component is housed therein.

- 1 46. The method of claim 35, wherein the system further includes a
2 calculating means, connected to the output of one of the analog to
3 digital converters and the controller, to calculate the at least one cell
4 voltage based on the digital values.
5
- 6 47. The method of claim 35, wherein each differential amplifier is adapted
7 to reject a common-mode voltage of at least +/-270 volts.
8
- 9 48. The method as claimed in claim 35, wherein the controller comprises a
10 microprocessor.
11
- 12 49. The method as claimed of claim 35, wherein the system further
13 comprises a computer and the controller is connected to the computer.